Assessment of the Contribution of Irrigation to Poverty Reduction and Sustainable Livelihoods

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ABSTRACT Irrigation in developing countries tends to be stereotyped as equity reducing, in competition with other uses for scarce water resources, and often resulting in negative impacts for women and other disadvantaged groups. Agricultural intensification through the practice of irrigation as a strategy for poverty reduction is examined. There are four inter-related mechanisms through which irrigated agriculture can reduce poverty. These are: improvements in the levels and security of productivity, employment and incomes for irrigating farm households and farm labour; the linkage and multiplier effects of agricultural intensification for the wider economy; provision of opportunities for diversification of rural livelihoods; and multiple uses of irrigation supply. There are also significant risks that badly designed and managed irrigation can negatively impact on poverty. It is concluded that irrigated farming varies widely in its form and impacts, and has diverse local attributes. Water resource management decisions must recognize this and be based on an holistic and livelihood-centred assessment of irrigation benefits and costs that goes beyond food production objectives.

Introduction
This review examines agricultural intensification through the practice of irrigation as a strategy for poverty reduction and promotion of sustainable rural livelihoods. In the international debate on water resource management, views of irrigation in developing countries tend to be polarized. On one side it is stereotyped as costly, a diversion of resources from rain-fed agriculture, equity reducing, in competition with other sectors for scarce water resources, and a cause of negative impacts for women, other disadvantaged groups and the environment. On the other, the proponents of irrigation raise the spectre of national food insecurity and higher food prices, given rising populations, incomes and urbanization. They emphasize the disproportionate contribution of irrigated farming to staple food production, for example citing that irrigated farmland produces over 40% of global cereals from about 17% of cultivated land Food and Agriculture Organization of the United Nations (FAO, 1996), and
together with high-yielding varieties and fertilizer contributed 92% of the near doubling of world grain production that took place between 1966 and 1990 (International Water Management Institute (IWMI), 2000). Both sides acknowledge contributions to poverty reduction, but even balanced observers remain defensive (see, for example, Strzepek et al., 2001). Irrigation is typically seen as a ‘necessary evil’, and the main challenges are to estimate the minimum required and optimize performance in terms of ‘crop per drop’.

This debate has given inadequate attention to irrigation’s potential for poverty reduction, and has failed to adequately connect with wider debates about the nature of poverty and the role of agriculture in economic growth. Indeed any rhetoric recognizing irrigation’s role in growth and poverty reduction is actually belied by the declining trend in investment in both construction and rehabilitation since the peak in the late 1970s (Jones, 1995), a decline that is all the more concerning given similarly declining investment in agriculture and rural development more generally (Rosegrant et al., 2002). This paper provides a framework for analysis of the impacts of irrigation on poverty and briefly reviews evidence from the literature. Conclusions highlight the characteristics of irrigated agriculture most likely to be poverty reducing, supportive investments and policies that are needed, and priorities for continued research.

How Irrigation Reduces Poverty: A Framework for Analysis

Dimensions of Poverty

An assessment of how irrigation can reduce poverty in developing countries must start from the widely accepted need for a broad conception of poverty and its determinants. Whilst income level is an important determinant of poverty, it is not sufficient as a measure. Indeed, many poor people in rural areas of developing countries may depend largely on their own productive activities for subsistence and have very little cash income. People may also be poor for structural reasons, lacking the resources and opportunities to establish a viable livelihood, and always having to struggle to meet basic needs. Alternatively they may be vulnerable to livelihood failure, falling into poverty during times of crisis such as periods of illness, crop failure or high livestock mortality. Poverty can also be considered in terms of lack of access to goods and services, for example health, education, roads, public transport and utilities; or in terms of deprivation of economic, political, social and cultural rights (Figure 1).

Poverty can be defined in absolute or relative terms. Absolute measures define a poverty line in real terms, while relative measures adjust this threshold to reflect levels of consumption and welfare in society as a whole. Poverty is also dynamic, its determinants varying both seasonally and from year to year. Assessment of how irrigation affects poverty must consider impacts on the varied dimensions of poverty, whether any changes are in absolute or relative terms, and whether they are long lasting or just transient.

How Irrigation Reduces Poverty

There are four major inter-related mechanisms through which irrigated agriculture can reduce poverty:

(1) improvements in the levels and security of productivity, employment and incomes for irrigating farm households and farm labour;
(2) linkages in the rural economy;
(3) increased opportunities for rural livelihood diversification; and
(4) multiple uses of water supplied by irrigation infrastructure.

Evidence for these mechanisms is only very briefly summarized here, but is reviewed in more detail by Hasnip et al. (2001). In assessing the first three of these, it is important to recognize the synergy, or complementarity, between use of irrigation and other innovations, particularly improved seed and fertilizer technology. From the available empirical evidence it is not usually possible to divorce assessment of the impact of irrigation from assessment of the impact of the ‘Green Revolution’ package of technology of improved seed and fertilizer use that has accompanied its use. For example, Evenson et al. (1999) found that irrigation investment in India generated growth in agricultural total factor productivity (TFP) over and above the contribution to output growth that irrigation as a conventional input makes by providing an improved environment for crop technology.

Direct productivity, employment and income effects. First, and most directly, where conditions are favourable irrigation can raise the incomes of those farmers with access to irrigated land. Water control in agriculture may boost productivity and incomes by:

- ensuring adequate water throughout the growing season, contributing to higher yields and quality (higher farm-gate prices) by eliminating water deficits and providing at least a measure of drought protection;
- securing a crop where rainfall is inadequate or too variable;
- allowing a second or even a third crop by making water available in the dry season;
• providing a cheaper or more secure supply of fodder for livestock (although irrigation may also involve some trade-offs with livestock production, as discussed below);
• allowing new crops or varieties for which market opportunities exist;
• improving timeliness and/or crop duration, allowing area expansion and/or increased cropping intensities;
• enabling farmers to adapt timing of production to market demand and higher prices, to take advantage of good weather conditions, or to avoid adverse weather extremes;
• in the case of tube-well irrigation, reducing flooding, waterlogging and soil salinization (noting that use of poor-quality groundwater can cause salinization, although in general effective drainage and water management can improve the quality of soils through leaching);
• reducing production risk and the need to borrow to smooth consumption, avoiding costs of credit access, indebtedness or need to dispose of assets; and/or the need for low-value subsistence diversification, allowing benefits from specialization or higher-value, higher-risk diversification into new crops or enterprises (although Hazell (1992) notes that whilst irrigation usually reduces variance in yields, output and employment for a farm or small region, it may increase variance in aggregate because of the increase in covariance as a higher proportion of output by crop type is concentrated in the irrigated area);
• reducing risk and raising returns in the use of complementary inputs such as improved seed and fertilizer;
• enabling management of the microclimate to reduce incidence of frost or low temperatures that damage crops;
• facilitating multiple farm enterprises around livestock, crops and agro-processing;
• raising farm household and hired labour productivity through all of these effects.

A further benefit arising for landowners may be appreciation of the value of land that has access to irrigation, often enhancing access to credit, and social standing and influence within the community.

Landless labour and marginal farm households that depend on labouring as a source of income will benefit from:
• increased, more continuous and more evenly spread farm employment and improved wage rates;
• reduced out-migration and increased return migration (seasonal or permanent);
• improved security against impoverishment and the need to dispose of assets or enter into debt.

Evidence for these effects is widespread, well documented and uncontroversial. For example, the FAO suggest that irrigation can increase yields for most crops by 100 to 400%, and that higher, less risky and more continuous levels of rural employment and income result from the higher cropping intensities, yields and more intensive and higher value crops and cultivation techniques of irrigated compared to rain-fed agriculture (FAO, 1996). Chambers (1988) cites several empirical studies across countries that show that irrigation directly raises em-
employment for landless labourers via increase in days worked per hectare, increase in days worked during a cropping season, and additional employment in a second or third irrigation season, and that this increase in demand for labour has a direct relation to increase in wage rates. For small farmers, irrigation typically means more use of family labour on their own land for an implicit wage higher than the best alternative, and/or hiring of labour at peak times. Counter-migration effects are of social and economic value if families stay together, children are sent to school, home improvements (for example sanitation) are undertaken, and the poor in the areas to which the out-migrants formerly went gain from reduced competition for jobs and higher wages. However, landless workers in rain-fed areas may still migrate long distances for work in irrigated areas (International Programme for Technology and Research in Irrigation and Drainage (IPTRID, 1999).

Linkages

Agriculture’s role in growth and poverty reduction. Recent research and accumulated empirical evidence support the renewed understanding that the central driver of poverty reduction is economic growth and, given the structure of developing economies (high proportion of gross domestic product (GDP) and employment in agriculture), that it is critical to support the productive activities of the rural poor (Dollar & Kraay, 2000; Fan et al., 1999; Thirtle et al., 2001). Agricultural growth is essential for sustained economic growth. It ensures investment in agriculture itself; it supplies food, raw materials and exports (freeing foreign exchange for import of industrial and capital goods); it releases surplus capital and labour to the non-farm sector; and it stimulates demand for local goods and services. It is also argued that in rural areas with poor communications and road networks there are few alternatives to farm-led growth. Only activities with a strong natural resource base (e.g. farming, fishing, forestry or tourism), local processing of farm products and non-tradable services for the rural population can survive (Wiggins, 2001).

Agricultural growth can thus drive economic growth, and when it is labour intensive it can be highly poverty reducing because it is geographically dispersed and ubiquitous in the rural areas where most of the poor live, utilizes their main asset and is massive in aggregate (Lipton, 1977). For example, Thirtle et al. (2001) found that for a sample of 40 countries the headcount index of poverty fell by close to 1% for every percentage increase in agricultural productivity, a higher figure than in other sectors. In addition, raising farm productivity raises incomes, but may also result in lower food prices. This will particularly be the case where the incremental output is large in aggregate, even if tradable (as with the Green Revolution in Asia), or for ‘semi’ or ‘non-tradable’ staples for which local demand will be constrained by local incomes and the size of the market. (This refers to international trade, or trade between districts and between urban and rural areas; whether something is tradable will depend on the size of an area and accessibility—i.e. on transport costs—and on comparative production costs inside and outside the area.) The price fall will increase consumers’ real incomes, particularly if the good commands a high average household budget share. This is poverty reducing because the majority of poor households in both rural and urban areas are net purchasers of staples, and because they spend a high proportion of their income on these (60% of expendi-
ture on food by people below the poverty line in Asia goes on cereals that provide as much as 70% of their total nutrients (IPTRID, 1999)). Whilst the large number of landless or marginal subsistence farmer rural households in Asia is well known, it is worth emphasizing that a majority of rural households in many regions of Africa are also net buyers of staple foods (Weber et al., 1988). There is also a positive correlation between nutritional status and the labour productivity of the poor (Dasgupta, 1998). This is enhanced as gains are in terms of not just physical productivity but also a greater ability to learn and invest labour and knowledge in livelihood improvements. Population growth may offset these effects by keeping food prices up and rural wages down, but overall agricultural productivity improvements have the potential to be both pro-poor and pro-growth (Thirtle et al., 2001).

It must also be noted that lower prices may offset producers' gains from higher productivity unless demand is relatively elastic or the gains in productivity are sufficient to sustain profitability through falling cost per unit of output. Successful irrigated farming will tend to achieve such cost reduction (as exemplified by the Green Revolution in India where gains in total factor productivity were sustained although price incentives were static or declined (Smith & Urey, 2002)), but other rain-fed or already irrigating producers in non-remote areas (i.e. integrated with wider markets) may lose from the lower prices.

Recognition that the sectoral composition of economic growth matters for poverty reduction is not new, but has been relatively neglected for two decades when the focus has been on macro policy, aid has neglected agriculture in favour of social service provision, and urban-oriented governments have not prioritized agricultural growth. This neglect is 'mirrored' in much of the international debate about water resources.

**Spreading the benefits of irrigation.** Irrigation contributes to agricultural growth by raising the productivity of land and labour (and complementary inputs such as improved seed and fertilizer). This benefits farmers and farm labourers directly, but linkages within the rural economy can also spread the gains more widely. Production linkages stimulate the farm input supply and output processing and distribution industries, while even larger effects can arise from consumption linkages as rural households purchase more goods and services. A consumption 'multiplier' follows if expanded demand for goods and services raises employment, further raising incomes in a virtuous circle that multiplies the benefits from the original gains in farm productivity. It is this combination of rapid productivity growth in farm and non-farm rural sectors, the latter consisting of suppliers of inputs, services and consumer goods to rural households, that produces an outcome that is most poverty reducing. This is reinforced when the increased incomes of rural households are spent on locally produced 'non-tradables' that are labour intensive, and for which supply is relatively elastic. It is also reinforced by the increase in real incomes for consumers (net purchasers) caused by lower food prices, but inhibited if price falls do offset productivity gains for net producers.

The importance of these linkages at the income levels of most poor countries is supported by empirical studies. Estimates of agricultural growth multipliers range from about 1.3 to 2.0, i.e. a 1% increase in agricultural output gives a 0.3–1.0% increase in non-agricultural output, and the bulk—75% or more—of these effects are shown to arise through consumption linkages (Delgado &
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Hopkins, 1998; Hazell & Haggblade, 1990; Thirtle et al., 2001). Hazell & Haggblade (1990) report for India that an increase of Rs100 in irrigated agricultural output stimulates Rs105 worth of additional manufacturing output and Rs114 additional tertiary output, a total non-farm multiplier of 2.19. Also often cited is a multiplier for irrigation development of 1.71 for the Muda Valley in Malaysia (Haggblade et al., 1991).

The precise form and degree of linkages will be affected by: rural infrastructure development, rural population density, the need for immediate and local processing of farm produce, the nature of technical change in farming, the tradability of goods and services demanded by farm households and the tradability of farm output. Areas with well-developed infrastructure and rural-urban links tend to show higher multipliers (Thirtle et al., 2001), but Delgado & Hopkins (1998) cite some equal or higher estimates for isolated African cases, arguing that any exogenous increase in farm incomes will be spent disproportionately on locally produced goods and services. Increased production of tradables may itself facilitate economies of scale and scope in communications and infrastructure provision, increasing the proportion of tradables in the local economy, but possibly at the expense of producers of non-tradables (for example traditional goods) (Govereh et al., 1999).

Some critics question the scale and attribution of these multipliers. Hart (1989) suggests that the Muda Valley estimates underplay increased spending on goods imported into the region and export of capital. Harriss-White (1997) also suggests that capital is exported from rural areas, and that the growth of rural industries owes more to links to urban hierarchies than to farming activity. Ellis (1998) asks if farming is always the core of the rural economy, or whether it receives net transfers of capital from non-farm sectors in contrast to the model of development where agriculture is the source of surpluses.

Other linkages are improvements in human capital through better nutrition (as noted above) and through increased ability to pay for health and education. Increased ability to save, to borrow and to invest in capital can also reduce vulnerability and contribute to productivity. It can also be speculated whether more social capital is generated if a thriving farm economy promotes links that establish trust and lower transaction costs and risks for farm and non-farm businesses (Thirtle et al., 2001), or if the need to manage irrigation infrastructure or the transport and marketing of increased crop surpluses stimulates more collective action.

Opportunities for rural livelihood diversification. Many rural households obtain a significant share of their income from, and devote much of their resources (especially labour) to, non-farm activities. Such diversification, defined as the process by which rural families construct a diverse portfolio of activities and social support capabilities in order to survive and to improve their standards of living (Ellis, 1998), can be a risk reduction and coping strategy (in response to shocks or chronic low returns in farming, or to seasonality of consumption, cash needs and labour requirements), or it can be a means for accumulation through exploitation of non-farm activities offering higher returns than farming. The first typically involves activities offering lower average returns to labour than farming, and may offer less vulnerability but no escape from poverty. The second provides higher and less variable incomes in aggregate, and may feed back into
agricultural growth by reducing risk aversion and financing inputs and capital investment.

Paradoxically, poor households with the greatest need to diversify out of agriculture may have most difficulty in engaging in higher-return non-farm activities because they lack the necessary human, social or financial capital. Opportunities for diversification in low barrier-to-entry non-farm employment or micro-enterprise that occurs locally rather than via out-migration are needed (Reardon et al., 2000). Compared to other sectors, only the production and consumption linkages of strong farm output growth are likely to generate these widely and in sufficient numbers in rural areas (Kydd et al., 2002; Reardon et al., 2000). If output growth is in tradables the opportunities may arise mainly via production linkages, and if in non-tradables via consumption linkages (Kydd et al., 2002). Thus irrigation has the potential to stimulate beneficial diversification for all rural households. In addition, less risky production of staples for irrigating farmers themselves allows them to bear more risk in new higher-return activities such as cash crops or non-farm enterprises.

Multiple uses of irrigation water supply. A further benefit for poor rural households is that they may derive multiple uses from water delivered by irrigation infrastructure. It can provide water for drinking, washing, homestead gardens and trees (outside formal command areas), livestock, replenishment of aquifers (including benefits of quality improvements and savings in time and energy for water lifting), urban water supply, rural industries, artisanal fishing and aquaculture. The quantities used may be small but of high value (e.g. horticultural or livestock production), and vital to viability of the activity, or to nutrition and health. Such water uses may be critical for women or other vulnerable groups. Thus recognition is needed that stakeholders with an interest in the water resources of an irrigation system may go beyond the owners and cultivators of land. Also, that when irrigation is seen as a ‘low-value’ water use compared to alternatives, this range of other uses may be being neglected (Bhatia, 1997; Meinzen-Dick, 1997; Yoder, 1983).

Risks to Poverty from Irrigation

Distributional impacts. Does irrigation deliver proportionally greater benefits to the relatively ‘rich’ even when it improves the absolute position of the poor (a deterioration in relative poverty)? Or, are there instances when irrigation may harm the poor and actually worsen absolute poverty? Evaluations of irrigation and the Green Revolution suggest that the first of these is most common but that the second is possible (Hasnip et al., 2001). Equity issues arise between geographical areas, and inter or intra households.

Technological change will inevitably be better suited to some regions than to others, and hence the first of these dimensions of inequity is generally unavoidable. Irrigation’s employment and linkage effects may benefit surrounding and wider areas, but inequities will tend to widen. If it occurs, depression of output prices for significant numbers of poor rain-fed net food producers is a concern. Rain-fed agricultural growth is also poverty reducing and should not be neglected.

Productivity-raising technologies have equitable on-farm benefits when: they are scale-neutral and can be profitably adopted on farms of all sizes; land
is equitably distributed with secure ownership or tenancy rights; efficient input, credit and product markets exist, giving all farms access to information, inputs and prevailing prices; and policies do not discriminate against small farmers and landless labourers (for example mechanization subsidies or anti small-scale biases in research and extension (Thirtle et al., 2001)). These conditions are rarely met by irrigation and it will usually reduce equity between households. Larger and relatively ‘resource-rich’ irrigators will benefit most, even if the poor usually still benefit in absolute terms.

Equity impacts of projects vary also with time, in terms of both nature and number of beneficiaries as well as extent of the benefits. In other words, this is a dynamic process, and the results five years after operation may be very different compared to those in 10 to 15 years’ time. Adoption of irrigation may be difficult for poorer farmers because it requires capital, familiarization and is cash intensive to operate. At first this raises inequality, as only few share the initially high income generated. If aggregate output is high enough, prices fall (particularly non-tradables) and non-adopting farmers may be worse off (although consumers gain). However, as adoption spreads inequality tends to fall. Thus again, irrigation is more likely to have widespread benefits if assets are equitably distributed and infrastructure, markets and social services well developed. Full equity impacts can only be assessed after a significant time lag, and policies to help adoption by the poorest may be merited (Kerr & Kolavalli, 1999).

Irrigation may worsen absolute poverty for some if it reinforces processes of land consolidation in which poor households lose rights to land, or if it is associated with displacement of labour by mechanization or herbicide use. Poor people may be displaced by the construction of reservoirs and canals, or their livelihoods may be adversely affected by upstream or downstream impacts. Badly designed or managed irrigation can negatively impact public health and human capital through the spread of water-borne diseases, usually with a greater incidence for the poor.

The consumption linkages that are major drivers of poverty reduction are likely to be less effective when income and land distribution are highly skewed. This is because the consumption patterns of the ‘wealthy’ may be oriented to imports and capital-intensive goods and services, rather than the offerings of rural non-farm suppliers.

Barriers to entry in non-farm employment and micro-enterprise can arise from ethnicity or caste, gender, skill and education levels, access to information, mobility, transaction costs and risks. Diversification may require investment in specific assets, and without functioning credit and insurance markets wealthy households are better able to invest and take risk. Farm households that can employ more labour (or substitute machinery) can also diversify without sacrificing farm output. Whilst contributing to inequity, these factors reinforce the proposition that only dynamic agricultural growth can create widespread diversification opportunities for the poor.

Equity with regard to multiple uses of water will depend on the pattern and nature of water rights, and how these are related to asset endowments and the ability of individuals and households to protect their rights. Stronger rights will apply even during water scarcity, whereas weaker rights tend to lapse, particularly if based on open access use of a water source or locally tolerated rights that have no legal basis.

Other risks more likely to adversely affect the poor include nutritional
concerns when irrigation leads to mono-cropping of cereals and neglect of pulses, oilseeds and coarse grains (for example under tube-well irrigation in Bangladesh). Livestock can also be an important asset and source of livelihood for the poor, but production may be constrained (with a greater tendency to small stock rather than large bovines) if seasonal or permanent grazing lands become irrigated (this has been observed for tube-well irrigation in Bangladesh by Angood et al. (2003a)). Alternatively, if land pressure is not too great, increased production of irrigated fodder and crop residues can facilitate a shift to more intensive rearing with stall feeding (observed, for example, on small schemes in Nepal by Angood et al. (2003b)).

Within households, women typically have less access to productive resources such as land, water, credit, training, fertilizer and marketing channels (Agarwal, 1994). This is significant because women are often responsible for generating food security for their families. Women’s crops, e.g. vegetables for household consumption, may have higher returns than crops grown by men alone or with the labour of their wives. Women can be pivotal in relation to poverty alleviation as they devote a larger share of their earnings to household food consumption, schooling and health care of children (World Bank, 1990). Irrigation usually requires more labour input per unit of land and it is often women who provide the additional labour. Women’s traditional tasks in agriculture—weeding and transplanting—increase with irrigation, whereas ploughing and land preparation, traditionally male tasks, may not. Training, credit, input delivery programmes and water delivery schedules that fail to take account of intra-household differentiation of labour, crop production and resource access can miss opportunities to reduce poverty by facilitating women’s activities.

Environmental impacts. The possible negative environmental impacts of irrigation are extensively documented elsewhere (see, for example, Dougherty & Hall, 1995; Goldsmith & Hildyard, 1992; Petermann, 1996). Most commonly cited are the upstream and downstream impacts of dams or diversions, waterlogging and salinization within command areas and increased agro-chemical usage. When these threaten the livelihoods of the poor they may worsen poverty. However, considering only direct negative impacts neglects three other viewpoints.

First, the causality of impacts, and whether it is poor design and construction or poor operation and maintenance, rather than irrigation per se, that result in this form of agricultural intensification being unsustainable. Second, positive impacts can arise through increased farmer ability to invest in land improvements that enhance sustainability (see, for example, Morrison & Pearce, 2000; Shively, 1999), or through less pressure on surrounding marginal areas (see, for example, Angood et al., 2003b; Asian Development Bank (ADB), 1993).

Third, a balanced view of the net contribution of irrigation to environmental change at a basin or regional level is required (Hasnip et al., 2001; Morrison & Pearce, 2000). Irrigation has indirect impacts through its net effects on farming practice. Given the essential role of agriculture productivity increase as an ‘engine’ of growth and poverty reduction, it is necessary to consider the ‘without-irrigation scenario’. How does extending the extensive margin of cultivation (ploughing of pasture, shortening of fallows, cultivating marginal land such as hillsides, etc.) compare to extending the intensive margin (use of improved varieties, agro-chemicals, more labour and notably irrigation)? Con-
considering on-site and off-site impacts, is irrigation more or less environmentally damaging than either intensifying or extensifying rain-fed cultivation? Where there is land pressure, inadequate means to intensify rain-fed farming and inadequate non-farm employment, out-migration will occur. This in turn will have environmental impacts in urban or rural areas that receive the migrants. The population absorption capacity of an irrigation-led strategy may be greater, and pressure on natural resources less severe, than for alternatives (Carruthers, 1996).

Appraising Irrigation

Appraisal of water allocation decisions and irrigation investment requires consideration of the contributions and risks to poverty reduction set out above (although it is beyond the scope of this paper to provide detailed guidelines).

Considering the dimensions of poverty, it is clear that irrigation can improve the incomes and consumption of poor people. The most important means for this are increased farm and non-farm employment, upward pressure on wages and lower food prices. This is because most poor people (including those in rural areas) gain an increasing share of their income from employment and are net food purchasers (although it is important to be aware of diversity and localized exceptions to this). The provision of opportunities for livelihood diversification is thus also very important.

Irrigation can also reduce income variance and enhance resilience to crises. As well as raising mean levels of output, employment, wages and incomes, it can reduce the variance of these (although possibly with increased covariance). Diversification of livelihoods can also reduce income variance and improve resilience.

Irrigation raises the productivity of assets; of labour, the main asset for most of the rural poor, and of land, for those with access to it. It also improves the ability of farm households to take advantage of new livelihood opportunities such as alternative higher-value crops, intensified livestock production and other market openings. Each in this range of benefits for farmers and labourers is enhanced when the complementarities of irrigation and other agricultural inputs are exploited.

Contributions from irrigation to empowerment, rights and freedoms for the poor are less clear, but the effects above may help to liberate people from indebtedness, increase access to decision-making processes, and support greater independence, self-confidence and assertiveness. It can be speculated that it may also promote and enhance the capability for collective action and community activities, and examples of this have been observed for case-study irrigation schemes in Nepal and Bangladesh (Angood et al., 2003a, b).

Increased ability to pay improves access to utilities, goods and services. This has also been observed in Nepal and Bangladesh, particularly for health and education (Angood et al., 2003a, b). Access to such services clearly depends on their provision, and here the relationship works both ways. Communications, market access and ease of transport of farm inputs and outputs are critical to achieving the full benefits of any irrigation investment. Conversely, where appropriate, investment in irrigation can capitalize on investments in roads, communications, market facilities and farm support services.

With regard to poverty dynamics, successful irrigation can lift people out of
poverty and reduce seasonal vulnerability, but in the longer run farm size may become limiting and incomes may ‘plateau’ without further technological or institutional advance (for example in seed technology, or via new market opportunities, land consolidation and improvement, or livelihood diversification). However, sustained farm-led poverty reduction requires sustained cost-reducing technological change, and this is currently more likely to be achievable with irrigation than without.

In achieving the poverty reduction benefits of irrigation, and avoiding the risks of worsening poverty, details of scale and technology matter. Low-cost and labour-intensive irrigation methods will tend to be more poverty reducing than large-scale, capital-intensive technologies, but it is at the farm rather than the system level that this matters most. The irrigation system itself need not be small as there are economies of scale in distribution systems, and the goal is an outcome from many small farms that is large in aggregate (although larger-scale water storage and delivery systems inevitably pose greater environmental risks, and require strong supportive institutions and governance).

Whether the system is large or small, irrigation technology that can be accessed by small and credit-constrained farms is needed. The spread of shallow tube wells in Bangladesh provides an example of this and, combined with emergence of water markets, has provided access to irrigation to even very marginal farmers. Irrigation policies, management and support services must also recognize intra-household differentiation and seek to exploit the poverty-reducing benefits of women’s roles and livelihood activities. Technology that creates demand for labour rather than replacing it is also needed, and agricultural research and extension systems should be oriented to support this. An important exception to this is that labour-intensive farming may not be appropriate where HIV/AIDS is leading to an erosion of the labour endowment of rural households. A labour (or energy) crisis may be occurring, and some households may revert to rain-fed rather than irrigated farming; also, for example, to hoe cultivation rather than ploughing, and from high- to low-labour crops such as roots instead of grains (de Waal, 2002).

Where irrigation is of higher cost, and/or water very scarce, production should concentrate on higher-value but still labour-intensive crops. Food security concerns may limit this to areas with good infrastructure and market access so that impacts on local staple prices can be mitigated by food imports. Differences in the linkage and multiplier effects for poverty reduction of higher-value versus staple crops need further research.

Deficiencies in the governance of irrigation systems have resulted in inequities in access to water, and in impoverishment for vulnerable small farmers. Introduction of irrigation into situations of extreme inequality in access to land, water and other assets will at best only result in much reduced contributions to the alleviation of absolute poverty, and will almost certainly result in further deterioration in relative poverty. Improvements in governance and effective institutions for water management are pre-requisites to public investment in irrigation in such areas.

Conclusions

Seventy-five per cent of the 1.2 billion people living below US$1 per day (1985 purchasing power parity) are rural, and in 2020 60% of the world’s poor will still
be rural (International Fund for Agricultural Development (IFAD, 2001). Thus reaching the Millennium Development Goals means giving high priority to rural development. Even when the rural poor are not engaged in their own farming, they rely on non-farm employment that usually depends on agriculture. This paper accepts the proposition that for most rural regions of low-income countries there are no alternatives to agricultural-led growth, and has explored the means by which irrigation may be a particularly effective means to promote both growth and poverty reduction.

This does not, however, mean that there should simply be more irrigation. Even if desirable, it is well known that the best sites have already been used, and that the construction and environmental costs of irrigation are rising whilst world prices for grains and most other widely traded crops have declined. The risks that irrigation may unacceptably worsen relative poverty, or even worsen the absolute poverty of vulnerable groups, are also real.

The point is rather that existing irrigation (for which capital costs are sunk) should be more highly valued and its poverty-reducing potential should be fully exploited. It should not be assumed that agriculture is a low-priority, or necessarily low-value, use for water. Nor that irrigation will inevitably only benefit already-wealthy landowners. Appraisal of investment in irrigation, and in the infrastructure and services that support dynamic farm growth, should assess returns in terms of potential growth and poverty reduction, and not just crop output. The objective should be jobs and poverty reduction per drop, and not just ‘crop per drop’. This accords with Chambers, a pioneer of livelihoods approaches, who argued that the generation and support of livelihoods is a higher priority than production per se (Chambers, 1988).

New irrigation developments should not be completely ruled out. Decisions must be subject to water scarcity and ideally made within an integrated water resource management strategy at basin level, but there is a strong case for facilitating private smallholder investment in irrigation (from treadle pumps and ‘bucket kits’ upwards) and aiming for productivity growth that is large in aggregate. Recognition of diversity in the characteristics of the poor, and in their physical and economic environment, should also be a key theme in policy making (Kydd et al., 2002). Thus public investment in new irrigation, although highly selective, should remain an option alongside other agricultural development pathways (for example rain-fed intensification, export cash crops, export livestock, etc.).

Poverty reduction through direct benefits, linkages and diversification (see above) can be achieved by growth in rain-fed or irrigated farming. What is less easy to determine from available evidence is whether irrigation’s impact on poverty per dollar of investment is likely to be greater than in rain-fed farming. One can argue in favour because of the greater intensity of the direct effects on farm productivity and incomes, and because there will typically be fewer technological, institutional and infrastructural constraints to success compared to rain-fed areas. Irrigated farming will tend to be more dynamic and richer in linkages, offering greater stimulus to non-farm micro-enterprises and employment. On the other hand, investment in rain-fed farming may reach more poor farm households directly, and will have linkage benefits that are widespread and may still be large in aggregate.

Other research needs include how best to match irrigation technology to the needs of poor people in different agro-ecological and institutional environments,
and how to improve appraisal and evaluation of the poverty impacts of irrigation investments; and finally, how the crucial employment and price multipliers vary, given variation in the demand characteristics of goods (for example, budget shares for different groups), tradability, and local production conditions and linkages.

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References
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Petermann, T. (1996) *Environmental Appraisals for Agricultural and Irrigated Land Development* (Zschorntau: German Foundation for International Development (DSE), Food & Agriculture Development Centre (ZEL)).


